SECTION

III

Future Conditions and Directions

Preface

Sections I and II have described water resource conditions within the Phoenix Active Management Area (AMA) and the regulatory programs designed to cause efficient use of groundwater and increasing amounts of renewable water supplies to be used. The Arizona Department of Water Resources' (Department) regulatory program for the third management period described in Section II represents the midpoint in our overall management strategy to implement water management programs which ultimately will lead to the achievement of the AMA's management goal by the year 2025.

This section, Section III, describes projected future conditions within the Phoenix AMA, as well as the directions the Department proposes to take in developing water management programs during the third management period.

Alternative future water supply and demand conditions are described in Chapter 11. The Department's supply and demand conditions, also known as "water budgets," are designed to illustrate a range of supply and demand possibilities for consideration as we develop our management programs. Both Phoenix AMA scenarios exhibit significant overdraft conditions; one more severe than the other. Chapter 11 projects continued overdraft scenarios even under optimistic conditions, indicating that mid-course changes in direction may be necessary if we are to achieve safe-yield by 2025.

Chapter 12 describes some options for the future, looking towards ultimately achieving the AMA management goal through increasingly stringent requirements for the conservation of groundwater along with the augmentation of water supplies. Chapter 12 summarizes existing water management problems, identifies the obstacles to safe-yield, and describes the actions the Department expects to take to remove these obstacles during the Third Management Period and beyond.

CHAPTER

11

Water Budgets and Projections

11.1 INTRODUCTION

The Arizona Department of Water Resources (Department) uses detailed water budgets to estimate total Active Management Area (AMA) water demand and supply. In this manner, the Phoenix AMA can evaluate the current imbalance or overdraft of groundwater to meet current demand in the AMA and the effectiveness various water management decisions have toward achieving the AMA goal of safe-yield of groundwater by the year 2025. After consideration of various possible future water management scenarios, the Phoenix AMA has developed water budgets for two scenarios of future water supply and demand through 2025. One scenario projects a continuation of the level of water use efficiency in the AMA in 1995 through the year 2025. The second scenario projects the effects of the Third Management Plan in improving water use efficiency. The projection scenarios are distinct future paths designed to assess the effectiveness of conservation requirements and augmentation efforts for the third management period and to reveal what will be needed in the fourth and fifth management periods to achieve the AMA's safe-yield goal.

11.2 WATER BUDGET SCENARIOS

The two water demand and supply projection scenarios are prepared based on many assumptions. In each scenario, only the assumptions that are key to fulfilling the objectives are varied; most assumptions remain the same for both of the scenarios. The following assumptions remain constant:

- Water demand for 1995 is the baseline for all projections.

- Water use rates for purposes such as residential landscape watering and agricultural crop watering are influenced by annual weather variation. To account for this, 1991 water use rates were used in the budget scenarios. The Department compared 1991 water use rates with long-term data and found that 1991 resembles long-term average annual weather conditions and water use rates more than any other recent year.

- Surface water availability can vary greatly from year to year. It is impossible to make long-term projections of surface water available year to year in the future with much accuracy. Historic long-term annual average surface water availability is the basis for future annual surface water availability in the water budget scenarios.

- Projections of population and urbanization of agricultural land are key factors for determining changes in agricultural, municipal, and industrial water use. As urbanization occurs, less land is available for agriculture. The 1995 AMA population estimate is based on municipal water service area population estimates developed by the Maricopa Association of Governments (MAG) for the Department. Population and land use projections for five year increments from the year 2000 through 2025 in the AMA are derived from 1993 Arizona Department of Economic Security projections for Maricopa and Pinal Counties. The population of the AMA is projected to grow from 2,549,931 in 1995 to 4,482,876 in 2025.

- Although urbanization of agricultural land caused by population growth will reduce non-Indian cropped acres through 2025, Indian communities are projected to considerably increase their cropped acres. Total cropped acres in the AMA (both on Indian and non-Indian lands) are projected to increase from approximately 200,000 acres in 1995 to approximately 227,000 acres in 2025.

- Natural system effects (recharge and underflow) are constant from year to year.

- Rates (but not volumes) of incidental recharge from agricultural, municipal, industrial, and other uses are constant from year to year.

- The volume of artificial recharge tallied in water budget scenarios in any given year is equal to: (1) the volume of recharge credits projected to be recovered in that year and (2) the quantity of artificial recharge that is considered a "cut to the aquifer" or the quantity stored that is ineligible for future recovery. Artificial recharge does not appear in the budget if it results in the accumulation of long-term storage credits which are not recovered by 2025.

- In the event of a water exchange, the water supply offered for exchange by the giving party is attributed to meet the demand of that party. For example, when a party exchanges groundwater for effluent, it is assumed for the water budget scenarios that the party used groundwater to meet its demand.

The two water budget scenarios are referred to as the Current Use Scenario and the Meet TMP Scenario for the remainder of the chapter. The objectives and key demand and supply assumptions are distinct for each scenario.

11.2.1 Current Use Scenario

This scenario measures groundwater overdraft in the AMA if current water use and supply utilization practices continue. This projection scenario assumes that water use efficiencies through the year 2025 by agricultural, municipal, and industrial users will remain at current levels. For example, it is assumed that the average household will be no more efficient in its water use in the year 2025 as it is today. Supply assumptions vary for the municipal, agricultural, and industrial sectors. Municipal supplies are prioritized based on compliance with Assured Water Supply Rules (non-Indian) or current sources (Indian). Agricultural supplies are prioritized based on source costs (non-Indian) or likely supplies available (Indian). Industrial supplies are largely groundwater and are projected to remain as such.

11.2.2 Meet TMP Scenario

This scenario measures groundwater overdraft if agricultural, municipal, and industrial users improve water use efficiency to meet Second Management Plan water use conservation requirements for each sector (chapters 4, 5, and 6, respectively) from 1995 to 2002, Third Management Plan conservation requirements from 2002 to 2010, and continue at this level of efficiency from 2011 to 2025. This scenario is designed to measure the effectiveness of the Third Management Plan conservation requirements toward meeting the safe-yield goal. Supplies are prioritized in the same manner as the Current Use Scenario.

11.3 OVERVIEW OF SECTOR DEMAND

Water use to meet demand in the Phoenix AMA is divided into municipal, agricultural, industrial, and riparian uses for analysis. Water supplies and uses are shown in Table 11-1 along with the percent of total water used by each sector in 1995 (more detailed information regarding current water use in the AMA is found in Chapter 3). Water use by the Indian communities within the AMA is not managed by the Department but is included in the AMA water budget scenarios. Water use figures for Indian communities are estimated for 1995 based on water rights settlement reports and hydrologic surveys.

TABLE 11-1
WATER USE SECTORS
PHOENIX ACTIVE MANAGEMENT AREA

Sector	Demand Characteristics	Supplier of Water / Legal Authority	1995 Volume / Percent of AMA Water Use
Municipal	- Non-residential industrial, commercial and institutional uses and residential uses - Urban irrigation served by large untreated water providers. - Effluent use at Palo Verde Nuclear Generating Station	- Cities and towns, private water companies, Indian communities, exempt wells - Large untreated water providers - 91st Avenue Wastewater Treatment Plant	869,962 acre-feet 37%
Agricultural	- Cultivation including Indian and non-Indian demand	Irrigation Grandfathered Groundwater Rights, irrigation districts and Indian community water rights	1,333,885 acre-feet 57%
Industrial	- Industrial, commercial and institutional uses served pursuant to a groundwater right or permit	Type I or Type II non-irrigation grandfathered groundwater rights; and groundwater withdrawal permits	83,088 acre-feet 4%
Riparian	- Riparian areas located along perennial areas of rivers and streams	N/A	48,000 acre-feet 2%

11.3.1 Municipal Demand

Total AMA municipal demand is composed of:

- Residential demand (household interior and exterior demand) and non-residential demand (commercial, industrial, and institutional uses) served by municipal water providers
- Residential and non-residential demand served within the Indian communities
- Urban flood irrigation served by large untreated water providers
- Lost and unaccounted for water from municipal provider and large untreated provider water systems

More information regarding municipal water use characteristics may be found in Chapters 3 and 5.

11.3.1.1 Municipal Demand Served by Municipal Water Providers and Indian Communities

Municipal demand served by municipal water providers and Indian communities is composed of residential and non-residential water uses and lost and unaccounted for water. Residential use constitutes interior and exterior use at single family and multifamily homes and apartments. Interior residential water use can vary with the number and efficiency of fixtures and appliances, water use practices, and the number of persons in a household. Exterior residential water use is dependent upon the type of landscaping at the residence, the type of irrigation system used and irrigation practices employed, and lot size. Non-residential use includes industrial, commercial, and institutional water uses served by municipal water providers and includes such uses as industrial processing, cooling, and landscaping. Since non-residential uses reflect the full range of economic activity in the AMA, the variables affecting water use can differ considerably from facility to facility. Lost and unaccounted for water results from leaking pipes, unmetered hydrant use, and other losses when water is conveyed in a municipal provider's water distribution system. The two water budget scenarios differ with respect to the degree of anticipated improvements in water use efficiency by new and existing residential and non-residential water uses served by municipal water providers as measured by gallons per capita per day (GPCD) water use.

To calculate non-Indian municipal provider water demand for each scenario, the AMA was divided into water planning areas. Water planning area boundaries usually correspond to municipal water provider boundaries and the supply source for the area (e.g., Gilbert outside of Salt River Project (SRP), Gilbert within SRP). MAG population projections for the AMA were disaggregated by water planning area and multiplied by a GPCD rate for that planning area. The AMA GPCD calculation shown in Table 11-2 is an average of the GPCD rates of each water planning area weighted by population. Different rates of population growth projected for each of the water planning areas will affect the AMA-wide average GPCD.

TABLE 11-2
ASSUMPTIONS FOR MUNICIPAL WATER DEMAND
SERVED BY MUNICIPAL PROVIDERS AND INDIAN COMMUNITIES
PHOENIX ACTIVE MANAGEMENT AREA

Factors	Projections			
	1995	2005	2015	2025
Population	2,549,931	3,016,643	3,704,394	4,482,876
Indian Reservation	12,053	12,520	13,004	14,457
Off Indian Reservation	2,537,878	3,004,123	3,691,390	4,468,419
GPCD - Current Use Scenario				
Indian	517	517	517	504
Non-Indian	238	235	234	232
GPCD - Meet TMP Scenario				
Indian	517	517	517	504
Non-Indian	238	219	212	207

GPCD = gallons per capita per day

Indian municipal water use is not subject to the AMA's conservation requirements, so the assumptions are the same for both scenarios. To calculate Indian municipal water demand, the latest published water settlement technical reports, hydrology reports, and population data were used. A GPCD rate for 1995 was estimated for each community based on this data. The estimated GPCD rate was then multiplied by population projections for the Phoenix AMA portion of the Gila River Indian Community and the Salt River Pima-Maricopa Indian Community to project water use for these communities. Because no population projections are available for the Fort McDowell Indian Community, municipal water demand is held constant from current estimated levels throughout the projection period. Differing population growth rates projected for each community explains the fluctuations over time in the weighted average GPCD rate for all Indian communities shown in Table 11-2.

The estimated 1995 GPCD rate for Indian communities seems extraordinarily high. Since many community households do not water elaborate landscaping, a major component of residential water use, GPCD rates were anticipated to be lower than the non-Indian average. Non-residential uses being developed within the Indian communities such as casinos, recreation facilities, and large retail developments with high water use characteristics spread across a small population base could also account for an unusually high per capita use rate. Lack of reliable data makes refining the projections difficult. However, since Indian municipal water demand accounts for less than 1 percent of total AMA water demand, the high degree of uncertainty associated with the projections will not greatly effect the water budget demand and groundwater overdraft calculations.

11.3.1.2 Urban Irrigation Demand Served by Large Untreated Water Providers

The number of landscaped acres irrigated, the irrigation requirements of the landscaping, and how water is applied to the landscaping (flood irrigation, sprinklers, etc.) are the primary factors influencing water demand for urban irrigation. The two water budget scenarios differ in how efficiently water is used to irrigate turfgrass. System inefficiencies, the practice of flood irrigation, and/or misguided or uninformed water management decisions by homeowners force more water to be applied to turfgrass than what it requires. The closer the amount of water applied to turfgrass comes to the actual consumptive use requirements, the less water is lost or wasted through inefficiency.

Large untreated providers are required by the Third Management Plan to limit deliveries for urban irrigation to 4.0 acre-feet per gross acre per year. Gross acres include acreage that is not landscaped and irrigated, such as buildings and driveways. Based on data submitted by large untreated providers on their 1995 annual water use reports, the current application rate is less than 4.0 acre-feet per gross acre. For this reason, the application rate per gross acre will not change and will remain the same for both scenarios (see Table 11-3). Irrigated acreage is assumed to be 60 percent of gross acreage and have a consumptive use rate of 3.6 acre-feet per acre. The remaining applied water is assumed to incidentally recharge the aquifer.

TABLE 11-3
ASSUMPTIONS FOR URBAN IRRIGATION WATER DEMAND
PHOENIX ACTIVE MANAGEMENT AREA

Factors	Projections			
	1995	2005	2015	2025
Irrigated Acres	29,741	30,833	33,355	36,066
Gross Acres	45,755	47,435	51,315	55,487
Application Rate (acre-feet/gross acre)	3.1	3.1	3.1	3.1

The Department consulted with large untreated providers to determine whether the provider would pursue new urban irrigation within their district. For both scenarios, new urban irrigation is projected for two large untreated providers - Roosevelt Water Conservation District (RWCD) and Maricopa Water District (MWD) - at a rate matching their projected population growth. As a result, urban irrigation acres are projected to increase by over 6,000 acres by 2025 (Table 11-3).

11.3.2 Agricultural Water Demand

Agricultural water demand is composed of Indian and non-Indian lands that are cultivated. Agricultural water use is a function of the total acreage which can legally be irrigated, the acreage of land actually cropped, the mix of crops planted, the efficiency of water use, the average consumptive use of crops, and any lost and unaccounted for water. More information on current and historic agricultural water use characteristics can be found in Chapters 3 and 4.

Both water budget scenarios assume rapid growth of the Phoenix metropolitan area will cause some non-Indian farmland to be urbanized and converted to non-agricultural uses, resulting in cropped acres declining from 161,797 acres in 1995 to 133,131 acres by 2025. The 1993 MAG land use projections were used to determine the number of cropped acres that are urbanized on a district by district basis. Where lands are urbanized, irrigation rights are likely to be inactivated and/or converted to Type 1 non-irrigation rights.

The underlying premise for the assumption that non-Indian cropped acres will decline rests with the price structure of water, not demand for crops. Lands which are in the path of new development and undergo the most urbanization - within the irrigation districts of SRP, MWD, and RWCD - have abundant surface water supplies and usually the lowest water costs per acre. Outlying irrigation districts that are removed from urbanization pressures are more heavily reliant on groundwater, which, with the possible exception of the Buckeye Water Conservation and Drainage District, have higher water costs than surface water districts. As a result, it is projected that no cropped acres will be established in the outlying areas to replace acres lost to urbanization closer to the Phoenix metropolitan area.

By contrast, cropped acres within the Indian communities are projected to increase through 2025 due to the agricultural development plans of the communities. Both scenarios assume that cropped acres on the Salt River Pima-Maricopa and Fort McDowell Indian Communities will grow by approximately 10 percent per year. The Gila River Indian Community is projected to aggressively increase farm acreage. The community's cropped acres are assumed to grow to nearly 76,000 acres in the Phoenix AMA portion of the Gila River Indian Community by 2025.

Different plants have different water needs. In 1995, the most common plants cropped in the AMA were cotton, wheat, and alfalfa. The future crop mix in the AMA is difficult to predict because federal subsidies and worldwide market conditions may change and these factors play a large part in determining the type of crops planted in the AMA. Future planting of crops with higher or lower consumptive use requirements than what is planted today would have significant effects on total agricultural water use. Because it is very difficult to predict long-term changes in crop mix in the AMA, future consumptive use requirements for both scenarios are assumed to remain constant with the 1995 weighted average consumptive use requirement for each irrigation district.

The water budget scenarios differ in how efficiently water is used to irrigate crops. System inefficiencies force more water to be applied to crops than what is needed. The closer the amount of water that can be applied to irrigated crops is to consumptive use requirements, the less water is lost or wasted through inefficiency. Table 11-4 illustrates the different assumptions regarding consumptive use of crops and efficiency for each of the water budget scenarios.

The weighted average consumptive use requirement for non-Indian lands is estimated to be approximately 3.8 acre-feet per acre. This figure is derived from the analysis of consumptive use requirements developed for the Second Management Plan. The weighted average consumptive use requirement for Indian lands is estimated to be approximately 3.6 to 3.7 acre-feet per acre. This figure is derived from estimates made within the latest published water settlement technical reports and hydrology reports.

Actual water use efficiencies by agricultural users are not reported to the Department annually. For the Current Use Scenario, non-Indian efficiencies were estimated by calculating weighted average efficiencies from Second Management Plan initial conservation requirements for areas of similar farming conditions. For the Meet TMP Scenario, non-Indian projections are based on meeting efficiencies found in the standard conservation requirements for agricultural users in Chapter 4. It is further assumed for this scenario that no agricultural users would enter the Historic Cropping Program (see Chapter 4). Indian agricultural water users are expected to steadily improve efficiencies through 2025.

Lost water results from seepage from canals and laterals and other losses when water is conveyed to agricultural lands. The two water budget scenarios include lost water reported to the Department.

TABLE 11-4
ASSUMPTIONS FOR AGRICULTURAL WATER DEMAND
PHOENIX ACTIVE MANAGEMENT AREA

Factors	Projections			
	1995	2005	2015	2025
Non-Indian Irrigation				
Cropped Acres, Both Scenarios	161,797	155,184	146,258	133,114
Consumptive Use, Both Scenarios (acre-feet/acre)	3.8	3.8	3.8	3.8
Irrigation Efficiency (%)				
Current Use Scenario	67	64	64	63
Meet TMP Scenario	80	80	80	80
Indian Irrigation				
Cropped Acres, Both Scenarios	37,956	63,748	82,248	93,575
Consumptive Use, Both Scenarios (acre-feet/acre)	3.6	3.7	3.7	3.7
Irrigation Efficiency (%) Both Scenarios	63	68	71	74

11.3.3 Industrial Water Demand

Industrial demand includes all users who pump or receive groundwater pursuant to non-irrigation grandfathered rights and withdrawal permits and may include any industrial, commercial, or institutional use. The largest water use within industrial demand is turf-related facilities, followed by dairies, sand and gravel operations, electrical power plants, feedlots, and large cooling towers (see Chapter 6).

Factors that influence water use vary with the type of industrial user. For turf-related facilities, the number of acres, the type of landscaping, and type and efficiency of landscape watering systems are principal factors. The number of lactating cattle, the number of milkings per day, and cooling practices are key factors affecting water use by dairies. Sand and gravel water use is driven by the quantity and quality of washed material and how much water is reused in the washing process. Cooling tower capacity and the frequency of water reused in the towers are the principal aspects of water use at electrical power plants and other facilities. Details of industrial water use may be found in Chapters 3 and 6.

Common assumptions of all water budget scenarios are the following:

- Turf-related facilities will grow approximately the same rate as population by 2025. Approximately 25 percent of new turf-related facilities from 1995 to 2025 will be industrial users (as opposed to facilities served by a municipal water provider whose water use is counted within municipal water demand). Water use for the Meet TMP Scenario is based on adjusting current water use rates to reflect all turf-related facilities in compliance with the Second and Third Management Plan conservation requirements.

- Sand and gravel operations and other industrial uses will grow commensurate with population.

- Reflecting past trends, feedlot water use will steadily decline, while dairy water use will steadily increase. For dairies, water use for the Meet TMP Scenario is based on adjusting current water use rates to reflect all turf-related facilities in compliance with the Second and Third Management Plan conservation requirements.

- Electrical power plants will remain unchanged from 1985 to 1995 average annual water use. Future additional power demand is projected to be met by sources outside the AMA.

TABLE 11-5
ASSUMPTIONS FOR INDUSTRIAL WATER DEMAND
PHOENIX ACTIVE MANAGEMENT AREA

Factors	Projections			
	1995	2005	2015	2025
Turf-Related Facilities				
Number of Industrial Facilities:				
Both Scenarios	110	130	152	177
Water Use (acre-feet):				
Current Use Scenario	49,227	57,451	66,795	77,294
Meet TMP Scenario	49,227	53,814	62,082	71,370
Dairies				
Number of Dairies:				
Both Scenarios	86	108	133	161
Water Use (acre-feet):				
Current Use Scenario	8,423	10,598	13,017	15,756
Meet TMP Scenario	8,423	9,807	12,045	14,579
Sand and Gravel Water Use (acre-feet)	8,278	10,416	12,793	15,485
Electric Power Water Use (acre-feet)	3,832	3,524	3,524	3,524
Feedlot Water Use (acre-feet)	809	788	768	748
Other Industrial Water Use (acre-feet)	12,519	15,752	19,348	23,418

11.3.4 Riparian Water Demand

In addition to agricultural, municipal, and industrial uses, evapotranspiration from vegetation growing along water courses contributes to water demand in the AMA. Riparian growth along the Salt and Gila Rivers is sustained in areas where the depth to groundwater is less than 20 to 30 feet below land surface and downstream from effluent releases into riverbeds from wastewater treatment plants. Most riparian growth in the AMA is located downstream from the 91st Avenue Wastewater Treatment Plant (WWTP) in Phoenix. Recent calibrations of a groundwater flow model for the Salt River Valley by the Department's Hydrology Division estimate 48,000 acre-feet per year of water is used by riparian growth in the AMA.

11.4 OVERVIEW OF SECTOR SUPPLIES

As described in detail in Chapter 2, municipal, agricultural, and industrial water demand in the AMA is met by four principal supplies:

- Surface water from rivers or their tributaries within the AMA, predominately the Salt, Verde, Gila, and Agua Fria Rivers, that is collected behind dams in regulatory storage reservoirs for use throughout the year;
- Colorado River water imported into the AMA by way of the Central Arizona Project (CAP);
- Effluent or water derived from human waste that is treated to sufficient quality so that it may be reused for certain uses; and
- Groundwater withdrawn from the six groundwater subbasins that make up the Phoenix AMA.

The Groundwater Code's (Code) goal of safe-yield of groundwater by the year 2025 for the Phoenix AMA necessitates prudent municipal, agricultural, and industrial water use efficiency coupled with maximum use of non-groundwater sources to achieve the goal.

Water is a physical resource and, as such, can be tracked and understood in purely physical terms. However, water management is becoming increasingly tied to legal accounting mechanisms for water. To maintain consistency with legal water accounting, groundwater overdraft projected in this chapter reflects legal water accounting rather than strict hydrological conditions. Using legal mechanisms for groundwater overdraft calculations addresses needs such as accounting for short and long-term storage of artificially recharged water and subsidizing the cost of renewable supplies, especially CAP, for non-potable purposes. For example, if effluent is stored at an Underground Storage Facility (USF), it is credited to the storer for future recovery. When recovery of the stored effluent occurs, the water is physically pumped from the ground, but legally it is considered effluent and is accounted for as such in the water budgets. Likewise, if an irrigation district is designated a Groundwater Savings Facility (GSF), the delivery of CAP water to substitute for groundwater pumping by the district is credited to the storer. The actual delivery and use of the supply is legally considered groundwater; future recovery of accrued credits will be considered CAP water. For further details, see Chapter 8.

11.4.1 Surface Water Other Than Central Arizona Project Water

In 1995, 1,004,593 acre-feet of surface water was used in the Phoenix AMA. Surface water availability, however, has been highly variable from year to year. Periods of drought have sharply reduced the volume of surface water within regulatory storage reservoirs. By contrast, in very wet years there has been insufficient storage capacity and it has been necessary to release spillwater from storage reservoirs. Projections for surface water availability in the water budget scenarios are based on historic long-term annual average diversions of each major surface water supply. Annual surface water availability for the Salt/Verde, Gila, and Agua Fria Rivers assumed in the water budget scenarios is found in Table 11-6.

Salt/Verde River water availability is based upon analyses done by SRP for the Department and the Bureau of Reclamation for determining municipal water provider consistency with the Assured Water Supply Rules (AWS Rules). In SRP's 1995 model run, total median water available at Granite Reef Diversion Dam was projected to be 833,000 acre-feet in the year 2040 (Keane, Emelity, and Anderson, 1996). However, this model run was completed prior to the raising of Roosevelt Dam and the resulting additional permanent storage capacity made available on the Salt/Verde system (see Chapter 2). An additional model run by SRP in 1997 projected an average annual yield of 73,800 acre-feet for New Conservation Space at Roosevelt Dam, for a total of 906,800 acre-feet available on the Salt/Verde River system.

TABLE 11-6
ASSUMPTIONS OF SURFACE WATER AVAILABILITY THROUGH 2025
PHOENIX ACTIVE MANAGEMENT AREA

Major River System	Annual Availability (acre-feet per year)
Salt/Verde Rivers	906,800
Gila River	68,170 increasing to 92,963
Agua Fria River	32,308

Gila River supply availability is the Phoenix AMA portion of the median amount of acre-feet diverted to the Pima Agency (Indian portion) of the San Carlos Indian Irrigation Project (SCIIP). Anticipated lining of the SCIIP canal system is expected to raise the amount of Gila River water available for use within the AMA by 2025. Agua Fria River supply availability is based on the maximum quantity reported by MWD to the Department.

In addition to Salt, Verde, Gila, and Agua Fria River water, very small quantities of other surface water supplies from Cave Creek, Queen Creek, and the Colorado River (that is not a part of CAP) are also included in the AMA water budget projections.

11.4.2 Central Arizona Project

An estimated 409,222 acre-feet of CAP water was delivered by the Central Arizona Water Conservation District (CAWCD) in the AMA in 1995 (CAWCD, 1996). This total includes direct use by municipal water providers, industrial users, and irrigation districts. It also includes water delivered to irrigation districts designated as groundwater saving facilities and legally accounted for as groundwater or CAP water stored in USFs for future recovery (see Chapter 8).

CAP water was originally allocated by the CAWCD to municipal and industrial users as well as agricultural users. However, when CAP water was finally available to users, the cost proved prohibitively expensive for most irrigation districts. By 1995, most agricultural irrigation districts had relinquished their CAP allocation subcontracts. In response, the CAWCD "pooled" this water and now offers it to users at a subsidized price. Pool 1 water is available to all agricultural entities who originally signed a subcontract. Pool 2 water is also available to those who waived certain subcontract rights. Pool 3 water is offered to any agricultural customer available who wants more than their allocated share of Pool 1 and Pool 2 water. For the water budget scenarios, it is assumed that Pool 1 water will continue to be offered through 2025, Pool 2 water will expire in 2003, and Pool 3 water will expire in 2011 (CAWCD, 1993).

CAP water has been allocated to the Indian communities within the AMA and is included in the scenarios. In recent years, several municipal water providers have worked to bolster their CAP allocations by acquiring or leasing unused allocations from outside the AMA. In addition, CAP allocations held by Indian communities may be leased by private developers or municipal water providers to serve future non-Indian municipal demand. For example, the lease of Indian CAP water to a non-Indian party (e.g., the lease of a portion of the Ak-Chin Indian Community's CAP right to Del Webb Corporation) is also included in the water budget scenarios.

Because future acquisitions or leasing arrangements are difficult to predict, it is assumed in both budget scenarios that municipal and industrial users with a municipal and industrial (M&I) allocation of CAP water will not acquire or lease any additional allocations of CAP water after 1998, either from Indian interests or from other M&I users throughout the state. However, future increases in municipal water use may cause the CAGRD to choose to lease CAP water to fulfill any obligations under the AWS Rules to replenish groundwater use by municipal users.

M&I users in the AMA have also used "excess" CAP water, or CAP water that has been allocated but remained unused in a given year, either by direct use or by storage at a GSF. The amount of "excess" water available in any year is dependent upon whether allocations remain unused throughout the state or whether a surplus is declared on the Colorado River. Given the difficulties in projecting future available "excess" CAP water, deliveries to the AMA of 677,000 acre-feet of CAP water for non-Indian uses is assumed throughout the entire projection period. This figure is based on actual deliveries to the AMA by the CAWCD in 1997 (CAP, 1998). It includes use based on M&I allocations (which total 312,749 acre-feet in 1998), "pooled" water made available to agricultural users, and "excess" water which is either directly used or artificially recharged.

Due either to a lack of existing or planned infrastructure necessary for direct use of CAP water, some M&I CAP allocations held by municipal providers are assumed to remain unutilized for direct uses. Such remaining CAP water is projected to be artificially recharged by municipal water providers for long-term storage credits.

11.4.3 Effluent

Effluent reuse within the Phoenix AMA continues to increase for all three sectors. The availability of effluent is calculated assuming 100 gallons of effluent are produced per person per day. Based on this assumption, an estimated 286,000 acre-feet of effluent was produced within the Phoenix AMA in 1995. Most of the effluent is produced at the 91st Avenue WWTP, of which 177,300 acre-feet per year of effluent is contracted to be piped from the plant to the Palo Verde Nuclear Generating Station (although 60,000 is approximately the maximum the facility has received as of 1998) and another 30,000 acre-feet is contracted to the Buckeye Water Conservation and Drainage District to irrigate crops (Maricopa Association of Governments, 1993). Through a water exchange agreement with the City of Phoenix, the Roosevelt Irrigation District is entitled to use up to 30,000 acre-feet of effluent per year, although Phoenix actually gets credited with the effluent use in their accounting (see Water Exchanges, A.R.S. § 45-1001, *et seq.*). Much of the remaining effluent from this plant recharges the aquifer or flows out of the AMA. Approximately 7,000 acre-feet of effluent from Chandler's Lone Butte WWTP is used to irrigate crops within the Gila River Indian Community. Much of the remaining direct use of effluent consists primarily of landscape watering by municipally served facilities and industrial users.

Based on the population projections for the AMA, approximately 502,000 acre-feet of effluent will be produced by 2025, an increase of 216,000 acre-feet from 1995. It is anticipated that the AWS Rules will cause municipal water providers to take greater advantage of effluent as a renewable supply and build future regional wastewater treatment plants in proximity to new development. These plants will allow municipal water providers to either use the effluent directly or artificially recharge it for long-term storage credits. Table 11-7 shows projections for total effluent production; the amount of effluent directly used by municipal, agricultural, and industrial users; the amount artificially recharged; the amount of natural recharge; and the amount remaining unused (discharge into riverbeds that either flows out of the AMA or is lost before recharging the aquifer).

Municipal water providers generally report little, if any, direct use of effluent to the Department. Projections of direct use of effluent by municipal water providers in the scenarios are probably conservative. In addition, the Department lacks data on effluent that may be released from wastewater treatment plants and not put to beneficial use. For these reasons, projections of artificial recharge are likely high and represent the maximum amount that may be artificially recharged in a given year.

TABLE 11-7
PROJECTED EFFLUENT USE THROUGH 2025
PHOENIX ACTIVE MANAGEMENT AREA

Type of Effluent Use	Projections (acre-feet)		
	2005	2015	2025
Direct Use			
Current Use Scenario	146,063	157,244	162,740
Meet TMP Scenario	144,709	159,170	159,446
Palo Verde Nuclear Generating Station	48,899	48,899	48,899
Maximum Artificial Recharge			
Current Use Scenario	102,771	168,629	250,334
Meet TMP Scenario	104,125	166,703	253,628
Incidental Recharge	46,000	46,000	46,000
Losses	43,073	43,073	43,073
TOTAL	337,907	414,945	502,147

11.4.4 Groundwater

In 1995, 946,052 acre-feet of groundwater was either withdrawn or received in lieu of pumping by municipal, agricultural, and industrial users in the AMA. For the water budget scenarios, it is assumed that users will be able to continue to annually pump groundwater up to the limits of their groundwater withdrawal authorities or what is allowable under AWS Rules. For both budget scenarios, significant quantities of unused allotments remain for both agricultural and industrial users throughout the projection period. Although provisions in the Code allow the Department to purchase and retire groundwater rights beginning in 2006, it is not included in the projection scenarios and does not act as a limiting factor for future groundwater pumping.

In 1997, the Legislature enacted legislation significantly revising the Water Quality Assurance Revolving Fund (WQARF) Program to provide incentives for the use of poor quality groundwater to facilitate the remediation of contaminated groundwater. The WQARF legislation provides that when determining compliance with management plan conservation requirements, the Department shall account for groundwater withdrawn pursuant to approved remedial action projects under the Comprehensive Environmental Response, Compensation and Liability Act or Title 49, Arizona Revised Statutes, consistent with the accounting for surface water. Laws 1997, Ch. 287, § 51(B). This legislation also provides that when determining the amount of allowable groundwater a provider may withdraw in accordance with the AWS Rules the Department shall account for groundwater withdrawn pursuant to approved remedial action projects, up to predetermined amounts, as consistent with the management goal of the AMA.

It is estimated as much as 175,000 acre-feet of poor quality groundwater could be remediated per year in the Phoenix AMA. However, given ongoing negotiations in this area, it is difficult to predict. For both scenarios, it is estimated that approximately 75,000 acre-feet per year will be remediated, based on known remedial action plans.

11.5 SUPPLY ASSUMPTIONS BY WATER USE SECTOR

The supply assumptions in the budget projections that are made for the municipal, agricultural, and industrial sectors reflect current water use patterns, the effects of complying with AWS Rules, water pricing, and the legal authority to source waters. Specific assumptions are listed below.

11.5.1 Municipal Water Supplies

Supply assumptions for non-Indian municipal water use, Indian municipal water use, and urban irrigation are distinct from one another in the water budget scenarios. Each component of municipal water use is listed separately below.

11.5.1.1 Supplies for Non-Indian Municipal Water Use

For all scenarios, the cities of Avondale, Chandler, Glendale, Goodyear, Mesa, Peoria, Phoenix, Scottsdale, Surprise, Tempe, the Town of Gilbert, Apache Junction Water Facilities District (formerly Consolidated Water Utilities of Apache Junction), and Chaparral City Water Company (Fountain Hills) are assumed to be designated under the AWS Rules. All other new non-Indian demand is anticipated to be met by Certificates of Assured Water Supply (Certificates of AWS) where applicable (see Chapter 5).

To meet water demand supplied by municipal water providers, supplies were prioritized based on a combination of the cost of supply sources, the availability of supplies to individual providers, and the likelihood or feasibility of using different supply sources for both scenarios. The Department made a preliminary determination of supply source priorities within each water planning area of the AMA (see section 11.3.1.1 for additional discussion of water planning areas). Municipal providers were asked to comment upon the priorities, and any resulting feedback was incorporated into the budget scenarios. The general order of priorities is as follows:

- SRP (to meet on-project demand only)
- Incidental recharge groundwater credit (AWS Rules)
- Other renewable supplies
- CAP water
- Direct use of effluent
- (A) accumulated recharge credits (designated providers under AWS Rules) or
  (B) a minimum CAGRD requirement (Certificates of AWS under AWS Rules)
- Allowable groundwater (AWS Rules)
- Mined groundwater obligated to be replenished with the CAGRD (AWS Rules)

The ranking of priorities was changed if feedback called for otherwise or if different water sources are available to the provider than what is listed above.

11.5.1.2 Supplies for Indian Municipal Water Use

In 1995, municipal and industrial water use on all three Indian communities was met by a combination of groundwater and surface water. Due to the lack of surface water treatment facilities, existing and new demand is projected to be met completely by groundwater for the Gila River and Salt River Pima-Maricopa Indian Communities and by surface water for the Fort McDowell Indian Community for both scenarios.

11.5.1.3 Supplies for Urban Irrigation

All demand as of 1995 is projected to be served by the same supplies delivered by untreated providers in 1995, which was a mix of groundwater, surface water, and CAP water, through 2025. Because surface water supplies of large untreated providers are fully committed to existing urban irrigation and other sector demands, any additional demand projected for urban irrigation above the 1995 level will be met by groundwater.

11.5.2 Agricultural Water Supplies

Supply assumptions for non-Indian and Indian agriculture differ in methodology and are discussed separately below.

11.5.2.1 Supplies for Non-Indian Agriculture

In both scenarios, cheaper water sources are assumed to rank higher in priority. Non-groundwater sources will be used prior to using groundwater, if available to an irrigation district. Irrigation grandfathered right holders outside of irrigation districts are assumed to pump groundwater. Right holders within irrigation districts that have a surface water supply other than CAP water are assumed to use surface water first and then move to in-lieu groundwater (in certain cases) or groundwater to meet demand. Right holders within irrigation districts that do not have a surface water supply other than CAP water are assumed to use CAP water first (Pool 1, Pool 2, and Pool 3), then move to using in-lieu groundwater, and finally to using groundwater.

11.5.2.2 Supplies for Indian Agriculture

The Salt River Pima-Maricopa Indian Community is assumed to continue its current supply mix of groundwater and surface water through 2000, after which it is assumed the community will reduce groundwater use and increase surface water use in accordance with its water rights settlement. The Fort McDowell Indian Community is assumed to use Verde River water for agricultural water demand throughout the projection period (this is consistent with the water rights settlement for the community). The Gila River Indian Community is anticipated to greatly increase use of CAP water to meet demand. Remaining demand not met by CAP water is projected to be met by Gila River water for lands within the SCIIP, SRP tailwater, effluent, and groundwater, in order of priority.

11.5.3 Industrial Water Supplies

All future industrial demand is projected to be served by the same supplies in the same proportion used in 1995. These include predominantly groundwater supplies but also include some surface water served by irrigation districts, "excess" CAP water not used by municipal and industrial users that hold a CAP allocation, and effluent from non-municipal sources.

11.6 CALCULATION OF GROUNDWATER OVERDRAFT

For the water budget scenarios, annual groundwater overdraft is calculated by subtracting recharge to the aquifer and other allowances from groundwater use created by municipal, agricultural, industrial, and riparian water demand outlined in section 11.3 above. If groundwater demand exceeds recharge, there is overdraft.

The calculation of groundwater overdraft requires the following subtractions from groundwater demand:

- Net natural system effects, such as groundwater underflow and natural recharge

- Incidental recharge of the aquifer caused by municipal, agricultural, and industrial water use
- AWS Rules, allowable groundwater
- AWS Rules, groundwater pumped with a replenishment obligation
- Benefits to the aquifer required by artificial recharge rules
- Benefits to the aquifer caused by the Arizona Water Banking Authority (AWBA)

These considerations are discussed below.

11.6.1 Net Natural System Effects

Net natural system effects are defined as the net naturally occurring additions to groundwater storage. Components of net natural recharge include mountain front recharge and ephemeral stream recharge. Also affecting groundwater storage is the net effect of groundwater underflow (groundwater inflow minus groundwater outflow). Net natural system effects in the AMA are estimated to contribute 24,100 acre-feet of water per year to the aquifer. Estimates of net natural system effect volumes have been revised since the Second Management Plan based on recent calibrations of components used in a groundwater flow model for the Salt River Valley in the AMA and other data. Components of net natural system effects are shown in Table 11-8.

TABLE 11-8
COMPONENTS OF NET NATURAL SYSTEM EFFECTS
PHOENIX ACTIVE MANAGEMENT AREA

Elements of Net Natural System Effects	Acre-Feet (AF)
Mountain Front Recharge	21,500 AF
Stream Channel Recharge	19,400 AF
Groundwater Inflow	11,800 AF
Groundwater Outflow	(28,600) AF
Total Net Natural System Effects	**24,100 AF**

Precipitation is the main source of water replenishing the aquifers as natural recharge. Mountain front recharge occurs in channels at the margins of mountain ranges, mainly the Superstition and McDowell Mountains. Mountain front recharge in the AMA is estimated at 21,500 acre-feet per year. Groundwater conditions in the Phoenix AMA may also be greatly affected by intermittent but occasionally large surface water flows (stream channel recharge) from the Salt, Gila, and Agua Fria River drainages and to a much lesser extent by intermittent, smaller flows from Cave Creek, Skunk Creek, New River, and Queen Creek. Surface water flows recharge the groundwater system as water infiltrates through the stream channel sediments to the underlying aquifers. Stream channel recharge on the Salt/Verde and Gila River systems, although historically and potentially very large in some years, is highly irregular and not reliable, occurring only when there is insufficient capacity to store water upstream. For this reason, median annual recharge, as opposed to mean annual recharge which may be skewed by flood events, is used in the budget scenarios. Because these estimates do not include the raising of Roosevelt Dam in the mid-1990s, which significantly increases the flood control capacity of the SRP, the long-term historic averages for stream channel recharge may be overestimated for future conditions.

Groundwater inflow to the Phoenix AMA occurs as groundwater flows north out of the Pinal AMA and into the Phoenix AMA near Florence and Sacaton into the East Salt River Valley Subbasin. Groundwater exits the Phoenix AMA from the Rainbow Valley Subbasin near Waterman Wash and the Maricopa-

Stanfield area and flows into the Pinal AMA. Groundwater inflow minus groundwater outflow yields a net groundwater loss of 16,800 acre-feet from the AMA.

Changes in the quantity of groundwater pumping and where pumping will occur may alter groundwater flow patterns in the AMA. However, the effect of future changes is hard to predict. Although groundwater underflow may change in the future, net natural system effects are held constant throughout the projection period.

11.6.2 Incidental Recharge

Incidental recharge is the amount of water which percolates down to the water table after it is used. In the Phoenix AMA, the volume of incidental recharge is largely dependent upon municipal and industrial demand and the quantity and efficiency of water applications to irrigated land. The percentage rate of incidental recharge for all sectors by scenario is shown in Table 11-9. Because the Meet TMP Scenario assumes that the conservation requirements will cause users to be more water efficient in certain instances, such as agricultural production, a lower volume of water is incidentally recharged as compared to the Current Use Scenario.

Other incidental recharge can occur in the AMA besides what is shown in Table 11-9. Incidental recharge from effluent flows released by the 91st Avenue WWTP into the Salt and Gila Rivers is projected to be 46,000 acre-feet annually (Table 11-7). The numerous irrigation district canals that crisscross portions of the AMA have seepage. It is projected that 85,000 acre-feet of water will be lost from the canals and seep into the aquifers annually.

TABLE 11-9
INCIDENTAL RECHARGE ASSUMPTIONS USED IN WATER BUDGET SCENARIOS
PHOENIX ACTIVE MANAGEMENT AREA

Rate Applied to Source of Recharge		Source of Incidental Recharge
Current Use Scenario	Meet TMP Scenario	
		Municipal demand:
4%	4%	• Municipal demand served by municipal water providers and Indian communities
24%	24%	• Urban irrigation
		Agricultural Demand
26%	15%	• Non-Indian agriculture
30% dropping to 21%	30% dropping to 21%	• Indian agriculture (sliding rate reflects efficiency improvements through 2025)
		Industrial Demand:
12%	12%	• Turf-related facilities and sand and gravel operations
0%	0%	• Dairies, feedlots, power plants
4%	4%	• Other industrial demand

11.6.3 Assured Water Supply Rules and Allowable Groundwater

The AWS Rules require consistency with the AMA's groundwater management goal of safe-yield. To that end, the AWS Rules in the Phoenix AMA limit the expansion of groundwater pumping in the municipal water use sector by shifting municipal users in growing areas to renewable supplies. The AWS Rules limit the amount of groundwater that designated providers and new developments coming under Certificates of AWS may use to meet the consistency with goal criteria for a 100-year supply. Because this quantity of groundwater or "allowable groundwater" has been found to be consistent with the management goal of safe-yield, it is subtracted from overdraft calculations for the water budget scenarios (see Chapter 5).

11.6.4 Assured Water Supply Rules and Replenishment Obligation

AWS Rules also require a designated provider or certificate holder that exceeds its allowable mined groundwater to replenish the aquifer with artificial recharge for the excess groundwater mined by contracting with the CAGRD for this purpose. In the water budget scenarios, groundwater mined in excess of allowable groundwater for new development has been assumed to be replenished as required by the AWS Rules. Thus, the net effect of this use is not considered a contributor to overdraft in the overdraft calculations for the water budget scenarios (see Chapter 5).

11.6.5 Artificial Recharge Cut to the Aquifer

CAP water, unappropriated surface water, or effluent may be artificially recharged into the aquifer to augment existing groundwater supplies for future use (see Chapter 8). When water is artificially recharged for use in later years, long-term storage credits accrue to the party storing water at an USF or deferring groundwater use at a GSF. In most instances of artificial recharge of CAP and unappropriated surface water, credits are limited to 95 percent of the water recharged. The remaining 5 percent is considered a "cut to the aquifer" and may not be recovered for use in the future.

Table 11-10 shows projections of the number of artificial recharge credits that will be earned through 2025 for each water budget scenario. Artificial recharge at GSFs is assumed to be equal to non-Indian agricultural demand met by in-lieu groundwater (section 11.5.2.1). Artificial recharge at USFs is assumed to be limited to CAP, effluent or other surface water supplies still available for use after projected demand has been met by either direct use of the supply or by in-lieu groundwater.

TABLE 11-10
PROJECTIONS OF MAXIMUM ARTIFICIAL RECHARGE
PHOENIX ACTIVE MANAGEMENT AREA

Scenario	Projections (acre-feet)		
	2005	2015	2025
Current Use Scenario			
Cap	463,830	432,604	399,016
Effluent	102,771	168,629	250,334
Surface	42,967	37,360	33,277
Meet TMP Scenario			
Cap	474,740	448,586	414,648
Effluent	104,125	166,703	253,628
Surface	42,228	36,557	33,277

Changes in supply availability and the quantity of direct use greatly affect supply availability for artificial recharge. The availability of CAP water to the AMA is especially uncertain (section 11.4.2) and direct use of effluent may be underestimated (section 11.4.3). The figures shown in Table 11-10 represent the maximum quantities projected to be artificially recharged.

In the water budget scenarios, the amount of artificial recharge that is a cut to the aquifer in a projection year is calculated based on the total artificial recharge of CAP water and unappropriated surface water projected to occur in that year. Because the cut to the aquifer cannot be used in the future, it is subtracted from total groundwater use when calculating overdraft in the water budget scenarios. All other artificial recharge is projected to be reserved for future use and is not used in overdraft calculations unless credits are recovered to meet demand.

11.6.6 Artificial Recharge by the Arizona Water Banking Authority

The AWBA is authorized to purchase unused Colorado River Water, bring the supply into central Arizona through the CAP aqueduct, and store it in existing aquifers for drought protection, enhanced water management, and other purposes. As a result, the AWBA will be a participant in CAP recharge projects in the AMA. A portion of the CAP recharge credits accumulated by the AWBA through these recharge activities are anticipated to be extinguished, preventing them from being recovered in the future. The CAP water recharged under these conditions becomes a permanent addition to the groundwater supply in the aquifer and is subtracted from total groundwater use when calculating groundwater overdraft. The volume of CAP recharge credits which will be extinguished by the AWBA has been projected based on estimating annual groundwater withdrawal fees which will be collected before 2017 (the current estimated date for cessation of AWBA activities) and assuming that the cost to recharge water into the aquifer is $70 per acre-foot. The projected volume of extinguished credits varies with water budget scenarios since the volume of groundwater withdrawal varies between scenarios (Table 11-11).

TABLE 11-11
PROJECTED EXTINGUISHMENT OF CAP RECHARGE CREDITS
BY THE ARIZONA WATER BANKING AUTHORITY
PHOENIX ACTIVE MANAGEMENT AREA

Scenario	Projections (acre-feet)			
	1995	2005	2015	2025
Current Use	0	31,168	33,433	0
Meet Third Management Plan	0	24,148	25,904	0

11.7 WATER BUDGET SCENARIOS

Tables 11-12 and 11-13 present the results of the Current Use Scenario and Meet TMP Scenario from 1995 through 2025 in ten year intervals. When the demand and supply assumptions for each sector are brought together into water budgets, it is apparent that both scenarios reveal continuing overdraft through the year 2025. Details of each scenario are described below.

11.7.1 Current Use Scenario

If no additional water use efficiencies are gained in the next 30 years, projected overdraft will increase from over 360,000 acre-feet in 1995 to over 471,000 by the year 2025. Overall demand will rise from over 2.3 million acre-feet in 1995 to over 2.9 million acre-feet by 2025, an increase of over 25 percent. Currently, the majority of water is used by the agricultural sector. By 2025, however, rapid population growth coupled with little change in water use by the agricultural sector result in changing the relative size of the two largest water use sectors, with agricultural water use falling to 46 percent of AMA water use and municipal water use increasing to 47 percent. Non-Indian municipal water will exceed non-Indian agricultural water use by 2010. The proportion of water used by the industrial sector is projected to change minimally through 2025.

Groundwater withdrawals are projected to initially drop through 2000 as municipal water providers convert to renewable water supplies to meet AWS Rules. However, this trend is short-lived as total water demand increases, and groundwater use in the AMA is projected to exceed 1995 levels from 2005 through 2025. Groundwater meets 41 percent of AMA water demand in 1995; this will not change by 2025. Most renewable supplies are expected to be artificially recharged for long-term storage credits and do not appear in the water budgets unless recovered for direct use.

11.7.1.1 Municipal Sector

As rapid population growth occurs in the AMA, the municipal sector's water use will increase dramatically, growing over 60 percent to nearly 1.4 million acre-feet by 2025. Most of the total municipal water use and most new demand is attributable to non-Indian residential and non-residential growth. Water use for urban irrigation and Indian municipal uses are projected to grow much more slowly. Overall, the municipal sector will become the largest water using sector in the AMA, growing from 37 percent of total AMA water use in 1995 to 47 percent by 2025.

Despite the growth in water use, adherence to AWS Rules is projected to initially cause a decline in groundwater use by the municipal sector as providers switch to renewable supplies. By 2015, however, groundwater use will rise to above the 1995 level. Although some of this rise is attributable to increased use of groundwater for urban irrigation and Indian municipal uses, most of the increase is due to an increase in groundwater use by the non-Indian municipal sector. Some of this groundwater is allowed under AWS Rules. Therefore it is deemed consistent with the management goal of the AMA and is subtracted from groundwater overdraft calculations for this reason. The municipal sector's proportion of the AMA's groundwater use initially falls from 27 percent in 1995 to 21 percent in 2005. However, because the sector's water use grows so rapidly, the proportion rises back up to 27 percent by 2025.

11.7.1.2 Agricultural Sector

Agricultural water demand is anticipated to rise through 2015, from 1.33 million acre-feet to 1.40 million acre-feet, then slowly fall through 2025 to 1.36 million acre-feet. The rise is solely attributable to an initially sharp increase in cropped acres and hence water demand on Indian lands. Indian water demand increases rapidly throughout the projection period. As the Indian communities approach the limit of developed acreage, growth in water demand slows later in the projection period. By contrast, non-Indian demand is projected to steadily decline throughout the period as urbanization overtakes agricultural land in the path of development.

Non-Indian groundwater use is projected to show little change annually over the 30-year projection period. This is largely due to a sharp increase in the use of in-lieu groundwater to replace Pool 1, 2, or 3 CAP water. Groundwater pumping, by contrast, is expected to steadily decline throughout the projection period. Although high levels of incidental recharge occur due to agricultural uses, non-Indian agriculture is projected to continue to use more groundwater than what is incidentally recharged into the aquifer from agricultural uses.

With the exception of the Gila River Indian Community, Indian agriculture is projected to be almost completely reliant on renewable supplies. However, because of rapid growth in agricultural acreage on the Gila River Community through 2020, total groundwater use steadily rises through 2020, then levels off.

Despite a proportionate decline in agricultural water use in the AMA from 57 percent in 1995 to 46 percent in 2025, the AMA's groundwater use by the agricultural sector will only slightly decline, from 61 percent to 60 percent.

11.7.1.3 Industrial Sector

Although projected to grow fairly rapidly, total industrial water use will remain a small proportion of the AMA's water use, accounting for 4 percent of AMA use in 1995 and 5 percent in 2025. Total water use is projected to grow from over 83,000 acre-feet to nearly 138,000 acre-feet. Although most new turf-related facilities are expected to be served by municipal water providers, rapid facility construction, notably golf course construction, leads to the rapid growth rate. Most interesting is the industrial sector's disproportionate contribution to groundwater use, accounting for 8 percent of the AMA's groundwater use in 1995, growing to 11 percent by 2025. Moving later into the projection period, it becomes apparent that the industrial sector is a relatively high contributor to overdraft given its small size.

TABLE 11-12
CURRENT USE SCENARIO DEMAND AND SUPPLY, 1995-2025
PHOENIX ACTIVE MANAGEMENT AREA

	1995	2005	2015	2025
Municipal				
Demand	869,962	998,997	1,188,898	1,395,725
Non-Indian	**862,987**	**991,752**	**1,181,367**	**1,387,556**
Indian	**6,975**	**7,246**	**7,531**	**8,169**
Supply	869,962	998,997	1,188,898	1,395,725
Non-Indian	**862,987**	**991,752**	**1,181,367**	**1,387,556**
Central Arizona Project	151,791	131,352	189,837	289,306
Direct Use	151,788	106,007	158,894	225,924
Credits Expended	3	25,345	30,943	63,383
Effluent	70,355	106,474	117,418	122,645
Direct Use	69,522	102,145	112,071	113,483
Credits Expended	833	4,329	5,347	9,162
Surface Water	393,091	548,147	622,921	673,011
Groundwater	247,750	205,779	251,191	302,594
Indian	**6,975**	**7,246**	**7,531**	**8,169**
Surface Water	1,140	1,140	1,140	1,140
Groundwater	5,835	6,106	6,391	7,029
Agricultural				
Demand	1,333,885	1,373,506	1,404,184	1,360,743
Non-Indian	**1,109,105**	**1,023,422**	**968,921**	**887,446**
Indian	**224,780**	**350,084**	**435,263**	**473,297**
Supply	1,333,885	1,373,506	1,404,184	1,360,743
Non-Indian	**1,109,105**	**1,023,422**	**968,921**	**887,446**
Central Arizona Project	121,238	74,461	50,527	50,527
Effluent	34,028	34,028	34,028	34,028
Surface Water	471,688	334,880	302,580	249,362
Groundwater	482,151	580,053	581,786	553,529
Direct Use	425,683	456,275	437,944	409,694
In-lieu of Use	56,468	123,778	143,842	143,836
Indian	**224,780**	**350,084**	**435,263**	**473,297**
Central Arizona Project	0	79,888	122,711	139,132
Effluent	2,325	2,325	2,325	2,325
Surface Water	131,424	138,188	146,047	158,888
Groundwater	91,032	129,683	164,180	172,952

TABLE 11-12
CURRENT USE SCENARIO DEMAND AND SUPPLY, 1995-2025
PHOENIX ACTIVE MANAGEMENT AREA

	1995	2005	2015	2025
Industrial				
Demand	83,088	99,933	117,649	137,628
Supply	83,088	99,933	117,649	137,628
Central Arizona Project	1,530	1,531	1,532	1,533
Effluent	3,023	3,236	3,473	3,741
Surface Water	7,250	8,307	9,485	10,813
Groundwater	71,285	86,859	103,158	121,540
Riparian				
Demand	48,000	48,000	48,000	48,000
Supply	48,000	48,000	48,000	48,000
Groundwater	48,000	48,000	48,000	48,000
Total Demand	**2,334,935**	**2,520,436**	**2,758,730**	**2,942,096**
Total Groundwater Use	**946,052**	**1,056,479**	**1,154,706**	**1,205,644**
(Less) Net Natural Recharge	24,100	24,100	24,100	24,100
(Less) Incidental Recharge	556,736	564,658	575,566	564,684
(Less) AWS Replenishment Obligation	0	2,027	23,041	51,992
(Less) AWS Allowable Groundwater	0	68,886	74,432	72,169
(Less) Artificial Recharge Cut to Aquifer	5,197	25,340	23,499	21,615
(Less) Arizona Water Banking Authority	0	31,168	33,433	0
Groundwater Overdraft	**360,019**	**340,301**	**400,636**	**471,085**

AWS = assured water supply

11.7.2 Meet TMP Scenario

If all non-Indian water using sectors meet Third Management Plan conservation requirements and continue at this level of efficiency through 2025, projected overdraft will initially decline from over 360,000 acre-feet in 1995 to approximately 284,000 acre-feet by 2005 and then increase to over 431,000 acre-feet by 2025. Overall water demand is substantially less in this scenario compared to the Current Use Scenario, amounting to over 2.6 million acre-feet in 2025, an increase of 12 percent from 1995. This is less than half the growth projected for the Current Use Scenario and reflects how moderate increases in water use efficiency can dramatically reduce water demand. Compared to the Current Use Scenario, the most precipitous drop in water use will occur in the non-Indian agricultural sector. Like the Current Use Scenario, the proportion of water used by the industrial sector is projected to change minimally.

Groundwater use is projected to be lower than 1995 levels through 2015, with a rise thereafter. Third Management Plan conservation requirements will sharply reduce the AMA's groundwater demand compared to the Current Use Scenario, reducing total groundwater demand by over 200,000 acre-feet in 2025. Cumulative groundwater savings throughout the projection period are estimated to be over 5 million acre-feet. Groundwater use will drop from 41 percent of total AMA water demand in 1995 to 38 percent by 2025.

11.7.2.1 Municipal Sector

The municipal sector's water use will increase to nearly 1.3 million acre-feet through the year 2025 under this scenario. Most of the growth in water demand is attributable to non-Indian residential and non-residential growth. As with the Current Use Scenario, water demand for urban irrigation and Indian municipal uses is projected to grow much more slowly than non-Indian municipal demand. Greater water use efficiency caused by the Third Management Plan GPCD requirements will reduce water demand by 129,000 acre-feet in 2025 as compared to the Current Use Scenario. Despite the reduction in water use, the relative size of the municipal sector will grow, rising to 48 percent of AMA water use by 2025 for both Indian and non-Indian demand.

In this scenario, groundwater use initially drops considerably as providers adjust their supplies to adhere to AWS Rules. Groundwater use rises after 2000 and increases above the 1995 level by 2025. Although some of this rise is attributable to increased use of groundwater for urban irrigation and Indian municipal uses, most of the increase is due to an increase in groundwater use by the non-Indian municipal sector.

Groundwater use is projected to be 48,000 acre-feet less by 2025 in this scenario compared to the Current Use Scenario. The municipal sector's proportion of the AMA's groundwater use initially falls from 27 percent in 1995 to 21 percent in 2010. However, despite reduced water demand in this scenario, the sector's growth in water demand remains relatively rapid compared to other sectors and the proportion rises after 2005 up to 26 percent by 2025.

11.7.2.2 Agricultural Sector

Agricultural water demand is anticipated to drop sharply after 1995 as non-Indian agricultural users meet Third Management Plan efficiency requirements. From 2000, total agricultural water use rises slightly until 2015 and then slowly falls through 2025. Non-Indian water use drops steadily through the projection period as cropped acres decline. The rise in total agricultural water use is solely attributable to increases in cropped acres and water use on Indian lands. Total agricultural water use under the Meet TMP Scenario is projected to be nearly 181,000 acre-feet less than the Current Use Scenario in 2025.

After an initial sharp drop through 2005, the volume of non-Indian groundwater use is projected to show little change annually over the 30-year projection period. Like the Current Use Scenario, this is largely due to a sharp increase in the use of in-lieu groundwater to replace Pool 1, 2, or 3 CAP water. Groundwater pumping, by contrast, is expected to steadily decline throughout the projection period. Despite lower overall demand than the Current Use Scenario, non-Indian agriculture is projected to continue to remain in groundwater overdraft through 2025. Indian agricultural water demand and supply is the same as the Current Use Scenario.

Because the Meet TMP Scenario projects a sharper decline in total water use by the agricultural sector as compared to other sectors when compared to the Current Use Scenario, the agricultural sector's proportion of water use in the AMA drops faster, from 58 percent in 1995 to 45 percent by 2025. Likewise, the agricultural sector's proportion of the AMA's groundwater use declines faster as compared to the Current Use Scenario, from 61 percent to 57 percent, although the decline is still minimal.

11.7.2.3 Industrial Sector

Water use projections for the industrial sector are not substantially different from the Current Use Scenario. Total industrial water use will remain a small proportion of the AMA's water use, accounting for 3 percent in 1995 and 5 percent by 2025. Total water use is projected to grow from over 83,000 acre-feet to nearly 131,000 acre-feet. It is projected that by 2025 the industrial sector's groundwater use will be

12 percent of the AMA's total groundwater use. Like the Current Use Scenario, the industrial sector is a growing contributor to overdraft.

TABLE 11-13
MEET TMP SCENARIO DEMAND AND SUPPLY, 1995-2025
PHOENIX ACTIVE MANAGEMENT AREA

	1995	2005	2015	2025
Municipal				
Demand	869,962	943,394	1,096,399	1,266,470
Non-Indian	**862,987**	**936,149**	**1,088,869**	**1,258,301**
Indian	**6,975**	**7,246**	**7,531**	**8,169**
Supply	869,962	943,394	1,096,399	1,266,470
Non-Indian	**862,987**	**936,149**	**1,088,869**	**1,258,301**
Central Arizona Project	151,791	117,944	165,534	236,976
Direct Use	151,788	102,320	149,209	208,018
Credits Expended	3	15,624	16,325	28,958
Effluent	70,355	105,380	119,662	119,735
Direct Use	69,522	101,287	114,675	111,624
Credits Expended	833	4,093	4,987	8,112
Surface Water	393,091	540,164	601,464	648,580
Groundwater	247,750	173,800	203,348	254,149
Indian	**6,975**	**7,246**	**7,531**	**8,169**
Surface Water	1,140	1,140	1,140	1,140
Groundwater	5,835	6,106	6,391	7,029
Agricultural				
Demand	1,333,885	1,168,137	1,208,020	1,179,184
Non-Indian	**1,109,105**	**818,733**	**773,437**	**706,567**
Indian	**224,780**	**350,084**	**435,263**	**473,297**
Supply	1,333,885	1,168,137	1,208,020	1,179,184
Non-Indian	**1,109,105**	**818,733**	**773,437**	**706,567**
Central Arizona Project	121,238	74,461	50,527	50,527
Effluent	34,028	34,028	34,028	34,028
Surface Water	471,688	291,008	264,789	219,963
Groundwater	482,151	419,046	423,413	401,369
Direct Use	425,683	317,798	302,141	280,062
In-lieu of Use	56,468	101,248	121,312	121,307
Indian	**224,780**	**350,084**	**435,263**	**473,297**
Central Arizona Project	0	79,888	122,711	139,132
Effluent	2,325	2,325	2,325	2,325
Surface Water	131,424	138,188	146,047	158,888
Groundwater	91,032	129,683	164,180	172,952
Industrial				
Demand	83,088	95,487	111,947	130,510
Supply	83,088	95,487	111,947	130,510
Central Arizona Project	1,530	1,531	1,532	1,533
Effluent	3,023	2,976	3,155	3,358
Surface Water	7,250	7,687	8,720	9,881
Groundwater	71,285	83,293	98,540	115,738

TABLE 11-13
MEET TMP SCENARIO DEMAND AND SUPPLY, 1995-2025
PHOENIX ACTIVE MANAGEMENT AREA

	1995	2005	2015	2025
Riparian				
Demand	48,000	48,000	48,000	48,000
Supply	48,000	48,000	48,000	48,000
Groundwater	48,000	48,000	48,000	48,000
Total Demand	**2,334,935**	**2,255,019**	**2,464,366**	**2,624,164**
Total Groundwater Use	**946,052**	**859,928**	**943,873**	**999,237**
(Less) Net Natural Recharge	24,100	24,100	24,100	24,100
(Less) Incidental Recharge	556,736	413,141	429,324	427,629
(Less) AWS Replenishment Obligation	0	1,490	17,890	41,340
(Less) AWS Allowable Groundwater	0	50,030	46,397	52,901
(Less) Artificial Recharge Cut to Aquifer	5,197	25,866	24,327	22,510
(Less) Arizona Water Banking Authority	0	24,148	25,904	0
Groundwater Overdraft	**360,019**	**321,153**	**375,931**	**430,756**

AWS = assured water supply

11.8 ANALYSIS AND DISCUSSION

The projections for each scenario illustrate continued groundwater overdraft throughout the projection period, with an approximate 40,000 acre-feet difference between the scenarios by 2025. Larger differences in overdraft between the two scenarios may have been expected. However, several of the components of each budget scenario are identical or similar. For example, the assumptions for Indian demand and supply, projected to be a substantial and growing component of AMA water use, are identical for both scenarios. Urban irrigation demand and supply is also identical for both scenarios. The difference in industrial water demand projected between the scenarios is small.

Where there are more substantial differences in water use demand, such as in the non-Indian municipal and agricultural sectors, countervailing factors work to draw groundwater overdraft together. Total non-Indian agricultural water demand is much lower in the Meet TMP Scenario compared to the Current Use Scenario. However, the reduction in groundwater use is much less and is offset by sharp reductions in incidental recharge from all sources of water caused by gains in water use efficiency to meet Third Management Plan requirements. In the non-Indian municipal sector, higher quantities of replenished groundwater are subtracted from groundwater overdraft calculations in the Current Use Scenario as compared to the Meet TMP Scenario, reflective of higher groundwater demand.

The groundwater overdraft calculations for the two scenarios reflect a sensitivity to several key assumptions as much as any statement regarding the effectiveness of Third Management Plan conservation requirements. Because of its relative size and water use characteristics, these assumptions tend to have the greatest bearing on agricultural demand and supply. Most notable is incidental recharge. Lack of reliable data for incidental recharge is true for all water use sectors and is a notable weakness of the scenarios. Only in the agricultural sector, however, does the lack of reliable data for current crop mix and water use efficiency have so much bearing on the quantity of incidental recharge and groundwater overdraft. Minor revisions to current incidental recharge rates in the agricultural sector could lead to substantial changes in the quantity of incidental recharge for this sector. These changes could result in larger differences between the Current Use Scenario, which is supposed to reflect current levels of incidental recharge throughout the projection period, and the Meet TMP Scenario where improved efficiencies result in less water being applied.

Other assumptions that are critical to the water budget projections are population and cropped acres. Both of these assumptions significantly impact the demand characteristics projected in both scenarios. However, the projections are also highly variable and subject to change with future economic conditions. While short-term population projections are highly accurate, long-term projections such as that found in the scenarios are of limited reliability. The number of future cropped acres, to a certain extent, is dependent upon population growth and urbanization location and density. Future crop pricing and farm subsidies, which are difficult to predict, determine the crop mix and acres farmed.

Overall, groundwater overdraft for both scenarios is projected to continue through the year 2025 and is more pronounced in certain sectors than in others. It is apparent from examining Tables 11-12 and 11-13 that the contribution to overdraft by the non-Indian agricultural sector will remain substantial despite a decline in cropped acres. Additionally, groundwater use and the contribution to overdraft by the industrial sector will increase and become a greater relative concern. Significant improvement is found in the municipal sector, as municipal providers take steps to convert to largely renewable supplies in accordance with the Department's requirements under the AWS Rules. It is apparent that safe-yield cannot be achieved so long as the "residual pumping" by agricultural water users, industrial water users, and municipal demand not subject to assured water supply requirements that has been allowed to continue without any replenishment remains.

It is important to note the difference between the accounting of groundwater shown in the water budget scenarios to meet demand and actual hydrologic conditions during the projection period. AWS Rules require either municipal water providers or new developments to demonstrate enough renewable supplies to maintain an assured water supply for 100 years. Consistent with the management goal of the AMA, only a limited portion of the demand may be met with groundwater. Municipal water providers are likely to make extensive use of renewable supplies, especially effluent, where they may never have in the past. Besides increasing utilization of renewable supplies for direct use, substantial quantities will likely be artificially recharged for long-term storage credits through 2025. Hydrologic conditions may actually be more favorable than what is inferred from the groundwater overdraft calculations shown in Table 11-12 and 11-13 through 2025. One reason for this difference may be the artificial recharge that has been stored but has not been recovered for use is not included in the calculations for overdraft. The reason for this is that the storage of water underground is not considered an existing use, rather a supply to meet future demands. Beyond 2025, as municipal providers begin to recover the stored credits, the hydrologic benefits of the recharge will not only end but likely reverse.

Because of the large size of the Phoenix AMA, the impacts of the demands must also be measured on a more localized scale, which the scenarios in this chapter do not address. In certain areas of the AMA, continual high levels of groundwater pumping may lead to detrimental, and possibly irreversible, negative impacts to the aquifer. Even if the projections do not portray a critical picture of groundwater overdraft on an AMA-wide basis, it will quickly become crucial to better manage all supplies in certain areas of the AMA. The future possibility that residual pumpers may be obligated to replenish groundwater use, and the substantial augmentation that may occur by municipal water providers driven by the AWS Rules, are opportunities to address severe over pumping in critical areas of the AMA. Actions also include alleviating waterlogging, whether by preventing waterlogging in the first place or by redirecting groundwater pumping to waterlogged areas from areas that are in severe overdraft.

The continued high demand for groundwater projected through 2025 demonstrates that safe-yield cannot be met, whether existing trends continue or if the conservation requirements of the Third Management Plan are adhered to by water users. Both scenarios illustrate that total AMA demand is increasing.

Agricultural uses are not projected to decline to the levels anticipated when the Code was implemented. Municipal population growth is projected to increase significantly with non-residential development in both the municipal and industrial sector growing to meet the needs of the additional population. Indian water use is also expected to increase in both the agricultural and municipal sectors in response to water rights settlements and improved economic development. All of this additional demand without commensurate improvements in efficiency of water use will put additional stress on both groundwater and renewable supplies. These scenarios illustrate that beyond the Third Management Plan additional conservation, renewable supply use, and replenishment obligations will be needed if the AMA is to achieve safe-yield. To what extent these additional mechanisms will be needed requires further examination.

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